

THE SEARCH FOR AGN IN DISTANT GALAXY CLUSTERS

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We are undertaking the first systematic study of the prevalence of AGN activity in a large sample of high redshift galaxy clusters. Local clusters contain mainly red elliptical galaxies, and have little or no luminous AGN activity. However, recent studies of some moderate to high redshift clusters have revealed significant numbers of luminous AGN within the cluster. This effect may parallel the Butcher-Oemler effect – the increase in the fraction of blue galaxies in distant clusters compared to local clusters. Our aim is to verify and quantify recent evidence that AGN activity in dense environments increases with redshift, and to evaluate the significance of this effect. As cluster AGN are far less prevalent than field sources, a large sample of over 120 cluster fields at $z > 0.1$ has been selected from the Chandra archives, and is being analysed for excess point sources. The size of the excess, the radial distribution and flux of the sources and the dependence of these on cluster redshift and luminosity will reveal important information about the triggering and fueling of AGN.

1. Status of Cluster AGN Studies

X-ray images are one of the most efficient ways to detect moderate to high redshift AGN. They are also highly effective for detection of galaxy clusters, through the diffuse emission from the intra-cluster medium. In one image it is possible to identify both the properties of the cluster and the probable number of X-ray sources associated with it by comparison to a blank field.

We have analysed two such clusters, MS1054-0321¹ (see O. Johnson et. al, this proceedings) and MS1512+36. Both clusters show a statistical excess of sources. MS1054-0321, a rich cluster at $z = 0.83$, has an excess of

luminous sources in the outer regions (1 - 2 Mpc from the cluster centre). In contrast MS1512+36 ($z = 0.37$) is a far poorer cluster and its excess sources are found in the central 1Mpc, and are an order of magnitude less luminous.

In addition to these two clusters, excess AGN have been found in the regions of five other clusters and two probable protoclusters (see discussion in Johnson et al.¹ 2003), spanning $0.15 < z < 2.16$. There is only one documented case of a high redshift cluster with no excess AGN² - however, many null results may go unpublished. In many cases spectroscopic and photometric observations have confirmed that the excess AGN do lie within the cluster³. From these seven clusters there is some evidence for evolution of the typical luminosity of the cluster AGN with redshift. The lower redshift clusters ($z < 0.3$) have excesses dominated by low luminosity sources. In the higher redshift clusters a population of more luminous sources emerges, but the small sample size makes any conclusions highly speculative.

2. Our Project: A Systematic Survey of Galaxy Clusters

What is clearly required now is a systematic study of a large, well defined sample of galaxy clusters in order to quantify the prevalence and form of AGN activity in dense environments at intermediate and high redshifts. We are undertaking a major project to study over 120 clusters at $z > 0.1$ from the Chandra X-ray Observatory archive. We have developed an automated pipeline to reduce the data, detect sources and analyse the results.

Our project will focus on the statistical excess of point sources in cluster fields compared to blank fields. Extensive calibration is being undertaken to determine the degree of field to field variation in non-cluster fields, and to identify any small systematic effects that could dominate over many fields. We will investigate the trends in the excess of point sources with cluster redshift, luminosity and morphology. In addition our automated pipeline analyses AGN luminosity and radial position within the cluster (as described for the two examples above) for all the clusters in the sample.

With this major survey, we will determine how the properties of cluster AGN depend on redshift and environment. This will identify some of the mechanisms that trigger or suppress AGN activity.

References

1. Johnson, O. et al. *MNRAS* **243**, 924J (2003)
2. Molnar, S. M. et al. *ApJ* **573**, L91 (2002)
3. Martini, P. et al. *ApJ* **576**, L109 (2002)